Memorandum

U.S. Department
of Transportation

Federal Aviation
Administration

Subject: **INFORMATION:** Engineering Brief No. 59
Item P-401 Plant Mix Bituminous Pavements
(Superpave™

Date: March 1, 2000

From: Manager, Engineering and Specifications
Division, AAS-200

Reply to
Attn. of:

To: All Regions
Attn: Manager, Airports Division

Engineering Brief No. 59 provides information and guidance on using asphaltic concrete mixtures designed with Superpave™ (Superpave™ is a trademark of the Strategic Highway Research Program) techniques. The guidance is intended for use in constructing the following pavements:

1. All pavements designed for gross aircraft weights of less than 60,000 pounds.

2. Taxiway and apron pavements for gross aircraft weights of 60,000 pounds or more.

An interim specification for mixtures designed with Superpave™ techniques is attached for your information and use.

The information in the brief is not to be construed as general approval by the Office of Airport Safety and Standards. Use of this brief on any AIP or PFC funded project is considered a modification to standards, with approval required at the Regional office level. This office requests notification and a note to the project files that ITEM P-401 PLANT MIX BITUMINOUS PAVEMENTS (SUPERPAVE™) was incorporated into the project specifications, when this brief is used.

ORIGINAL SIGNED BY
John L. Rice

Attachment

ENGINEERING BRIEF NO. 59
ITEM P-401 PLANT MIX BITUMINOUS PAVEMENTS (SUPERPAVE™)

PURPOSE: The purpose of this engineering brief is to provide guidance on using asphaltic concrete mixtures designed with Superpave™ techniques.

DEFINITION: An asphaltic concrete mixture designed using Superpave™ techniques is defined as an asphalt mixture designed using general guidance found in two manuals published by the Asphalt Institute;

1. Superpave™ Level 1 Mix Design, Superpave™ Series No. 2 (SP-2), and

2. Performance Graded Asphalt Binder Specification and Testing, Superpave™ Series No. 1 (SP-1).

The guidance contained in the above publications has been modified and inserted into several provisions of the attached interim specifications to reflect adaptations believed necessary to maintain the level of safety and performance expected from airport pavements. The Superpave™ related modifications were reviewed by The National Center for Asphalt Technology (NCAT) during January 2000.

BACKGROUND: From October 1987 through March 1993, the Strategic Highway Research Program (SHRP) conducted a $50 million research effort to develop new ways to specify, test, and design asphalt materials. The SHRP and development of related products and technology was and continues to be administered by the Federal Highway Administration (FHWA). One product is a new system for asphaltic concrete pavements, referred to as Superpave™, which stands for Superior Performing Asphalt Pavements. It represents an improved system for specifying the components of asphalt concrete, asphalt mixture design and analysis, and asphalt pavement performance. In 1994, the Federal Aviation Administration funded studies by the U.S. Army Corps of Engineers to evaluate SHRP products for applications to airport pavements. The study indicates that using asphaltic concrete mixtures designed with Superpave™ techniques is not directly applicable to heavy-duty airport pavements. However, the system may prove adequate and directly applicable to light-duty airport pavements.

Recent improvements and refinements to the Superpave™ mixture design parameters and the apparent successful use of these modifications on a recent project in Ainsworth, NE, has resulted in additional requests to use Superpave™ mixtures. Many of the provisions in the interim specification have been adopted in provisional specification published by the American Association of State Highway Transportation Officials (AASHTO). In addition, performance graded asphalt grade bumping guidance, believed to be consistent with Asphalt Institute, AASHTO provisional guidance, and discussions with NCAT officials is included.

Information and references to SHRP and Superpave™ are available on the world-wide web sites for the FHWA, AASHTO, and NCAT.

ACKNOWLEDGEMENT: A draft specification was prepared in December 1999 with the assistance of the FAA Central Region Paving Engineer and the engineering firm responsible for the design and construction administration for the Ainsworth, NE project. The attached specification was reviewed by NCAT officials, and all NCAT comments were incorporated. The AASHTO provisional guidance for performance graded asphalt grade bumping, was provided by the Asphalt Institute.

APPLICATION: The guidance is intended for use in constructing the following pavements:

1. All pavements designed for gross aircraft weights of less than 60,000 pounds.

2. Taxiway and apron pavements for gross aircraft weights of 60,000 pounds or more.

When the attached interim specification is used on any Airport Improvement Program (AIP) or Passenger Facility Charge (PFC) funded project, notification of this office and a note to the project files that ITEM P-401 PLANT MIX BITUMINOUS PAVEMENTS (SUPERPAVE™) was incorporated into the project specifications, is requested.

SPECIFICATION: Attached is an interim specification for constructing plant-mix bituminous pavements using asphaltic concrete mixtures designed with Superpave™ techniques. The specification includes all AC 150/537-10A Item P-401 changes thru Change 12. Material and test methods that have changed since the issue of Change 12 and minor editorial changes have been included in this interim specification.

ORIGINAL SIGNED BY
Jeffrey L. Rapol
Civil Engineer

ITEM P-401 PLANT MIX BITUMINOUS PAVEMENTS (SUPERPAVE™)

DESCRIPTION

401-1.1 This item shall consist of a **[ ]** course composed of mineral aggregate and bituminous material mixed in a central mixing plant and placed on a prepared course in accordance with these specifications and shall conform to the lines, grades, thicknesses, and typical cross sections shown on the plans. Each course shall be constructed to the depth, typical section, or elevation required by the plans and shall be rolled, finished, and approved before the placement of the next course.

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Specify surface and/or leveling course(s).

This specification is intended for use in constructing the following pavements using mixtures designed with Superpave™ techniques: (Superpave™ is a trademark of the Strategic Highway Research Program)

1. All pavements designed for gross aircraft weights of less than 60,000 pounds.
2. Taxiway and apron pavements for gross aircraft weights of 60,000 pounds or more.

State highway department specifications may be used for access roads, perimeter roads, stabilized bases courses under Item P-501, and other pavements not subject to aircraft loading.

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MATERIALS

401-2.1 AGGREGATE. Aggregates shall consist of crushed stone, crushed gravel, or crushed slag with or without sand or other inert finely divided mineral aggregate. The portion of materials retained on the No. 8 sieve is coarse aggregate. The portion passing the No. 8 (2.36 mm) sieve and retained on the No. 200 (0.075 mm) sieve is fine aggregate, and the portion passing the No. 200 (0.075 mm) sieve is mineral filler. All aggregate property tests shall be conducted by an accredited laboratory that meets the requirements of section 401-3.5. Aggregate test results shall not be greater than 6 months old. If test results are provided on the combined blend, the Engineer reserves the right to require tests on individual aggregates should a major change in the Job Mix Formula percentages occur.

a. Coarse Aggregate. Coarse aggregate shall consist of sound, tough, durable particles, free from adherent films of matter that would prevent thorough coating and bonding with the bituminous material and be free from organic matter and other deleterious substances. The percentage of wear shall not be greater than 40 percent when tested in accordance with ASTM C 131. The sodium sulfate soundness loss shall not exceed 10 percent, or the magnesium sulfate soundness loss shall not exceed 13 percent, after five cycles, when tested in accordance with ASTM C 88.

*** ***

Percentage of wear shall not exceed 40 for surface and intermediate courses; sodium sulfate loss should not exceed 10 percent; magnesium sulfate soundness loss should not exceed 13 percent. Aggregates with a higher percentage loss or wear may be specified, provided a satisfactory service record under similar conditions of service and exposure shall have been demonstrated.

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The combined coarse aggregate material shall contain at least 85 percent by weight having at least one fractured face and 80% by weight having a minimum of two (2) fractured faces. The fractured faces percentage for any crushed gravel aggregate material, retained on the No. 8 (2.36 mm) sieve after crushing, shall be determined in accordance with ASTM D 5821. The area of each face shall be equal to at least 75 percent of the smallest midsectional area of the piece. When two fractured faces are contiguous, the angle between the planes of fractures shall be at least 30 degrees to count as two fractured faces. Fractured faces shall be obtained by crushing.

The aggregate shall not contain more than 8 percent, by weight, of flat or elongated pieces, when tested in accordance with ASTM D 4791 using a ratio of 5:1.

Slag shall be air-cooled, blast furnace slag, and shall have a compacted weight of not less than 70 pounds per cubic foot (1.12 mg/cubic meter) when tested in accordance with ASTM C 29.

b. Fine Aggregate. Fine aggregate shall consist of clean, sound, durable, angular shaped particles produced by crushing stone, slag, or gravel that meets the requirements for wear and soundness specified for coarse aggregate. The aggregate particles shall be free from coatings of clay, silt, or other objectionable matter and shall contain no clay balls. The fine aggregate, including any blended material for the fine aggregate, shall have a plasticity index of not more than 6 and a liquid limit of not more than 25 when tested in accordance with ASTM D 4318.

Natural (nonmanufactured) sand may be used to obtain the gradation of the aggregate blend or to improve the workability of the mix. The amount of sand to be added will be adjusted to produce mixtures conforming to requirements of this specification. **[The fine aggregate shall not contain more than 15 percent natural sand by weight of total aggregates.]**

The fine aggregate material shall have sand equivalent value of 40 or greater when tested in accordance with ASTM D 2419. The fine aggregate material shall have a Fine Aggregate Angularity of not less than 45 when tested in accordance with AASHTO T304, Method A.

* *

The addition of natural sand to a mix containing all crushed coarse and fine aggregates will normally increase its workability and compactability. However, the addition of excessive amounts of natural sand tends to decrease the stability of the mixture. The requirement for a maximum of 15 percent natural sand may be included for locations where low stabilities are a chronic problem.

* *

c. Sampling. ASTM D 75 shall be used in sampling coarse and fine aggregate, and ASTM C 183 shall be used in sampling mineral filler.

401-2.2 MINERAL FILLER. If filler, in addition to that naturally present in the aggregate, is necessary, it shall meet the requirements of ASTM D 242.

401-2.3 BITUMINOUS MATERIAL. The bituminous material shall conform to the requirements of AASHTO MP1, performance graded binder designation PG**[ ]**. A certificate of compliance from the manufacturer must be included with the mix design submittal.

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Note to Engineer -- Specification of Performance Graded asphalt should be consistent with the recommendations of the applicable State Department of Transportation and be locally available. In the absence of guidance from a state DOT, the recommendations from the Long Term Pavement Performance Binder Software, LTPPBind.exe should be used in conjunction with Table A. In general, a high reliability (98 percent) on both the high and low temperature categories is sufficiently conservative. Grade bumping of performance graded binders is permitted, and interim guidance is provided in Table A.

Table A. Binder Grade Selection and Grade Bumping Based on Gross Aircraft Weight.

Determine binder requirements from LTTP Bind version 2.1 using 98 percent reliability with no traffic or speed adjustments. Increase the high temperature grade by the number of grade equivalents indicated (1 grade is equivalent to 6 degrees C) below. Use the low temperature grade as determined from LTTP Bind version 2.1. (see NOTES)		
Aircraft Gross Weight (pounds)	**High Temperature Adjustment to Binder Grade**	
	Pavement Type	
	Runway	**Taxiway/Apron**
Less than 12,500	**--**	**--**
Less than 60,000	**--**	**1**
Less than 100,000	**NA**	**1**
Greater than 100,000	**NA**	**2**
NOTES: **1. PG grades above a –22 on the low end (e.g. 64–16) are not recommended. Limited experience has shown this to be a poor performer.** **2. PG grades below a 64 on the high end (e.g. 56-22) are not recommended. These binders often provide tender tendencies.** **3. PG grades above a 76 on the high end (e.g. 82-22) are not recommended. These binders anr very stiff and difficult to work and compact.**		

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The Contractor shall furnish vendor's certified test reports for each lot of bituminous material shipped to the project. The vendor's certified test report for the bituminous material can be used for acceptance or tested independently by the Engineer.

401-2.4 PRELIMINARY MATERIAL ACCEPTANCE. Prior to delivery of materials to the job site, the Contractor shall submit certified test reports to the Engineer for the following materials:

a. Coarse Aggregate.

(1) Percent of wear.
(2) Soundness.
(3) Unit weight of slag.
(4) Coarse Aggregate Fractured Faces Determination (Coarse Aggregate Angularity).

b. Fine Aggregate.

(1) Liquid limit.
(2) Plastic index.
(3) Sand equivalent.
(4) Fine Aggregate Angularity.

c. Mineral Filler.

d. Bituminous Material. The certification(s) shall show the appropriate AASHTO test(s) for each material, the test results, and a statement that the material meets the specification requirement.

The Engineer may request samples for testing, prior to and during production, to verify the quality of the materials and to ensure conformance with the applicable specifications.

COMPOSITION

401-3.1 COMPOSITION OF MIXTURE. The bituminous plant mix shall be composed of a mixture of well-graded aggregate, filler if required, and bituminous material. The several aggregate fractions shall be sized, handled in separate size groups, and combined in such proportions that the resulting mixture meets the grading requirements of the job mix formula (JMF).

401-3.2 JOB MIX FORMULA. No bituminous mixture for payment shall be produced until a job mix formula has been approved in writing by the Engineer. The bituminous mixture shall be designed using the procedure contained in Chapter 5, Superpave™ Level 1 Mix Design, of the Asphalt Institute's Manual Superpave™ Series No. 2 (SP-2), Superpave™ Level 1 Mix Design, and shall meet the requirements outlined below. The Contractor shall determine the Marshall stability and Marshall air Voids of the JMF at the design asphalt cement content using a 75-Blow Marshall tested in accordance with ASTM D-1559 (93) or AASHTO T 245.

The Tensile Strength Ratio (TSR) of the composite mixture shall be greater than or equal to 80 when tested in accordance with ASTM D 4867 including the freeze-thaw conditioning cycle. Test specimens shall have an air void content of 6 to 8 percent and a degree of saturation of 55 to 80 percent. If an anti-stripping agent is required, it shall be provided by the Contractor at no additional cost.

The job mix formula shall be submitted in writing by the Contractor to the Engineer at least **[ ]** days prior to the start of paving operations. The job mix formula shall have been developed no more than 3 months prior to submittal and shall include as a minimum:

a. Percent passing each sieve size for total combined gradation, individual gradation of all aggregate stockpiles and percentage by weight of each stockpile used in the JMF.

b. Percent of asphalt cement.

c. Asphalt Performance Grade.

d. Number of gyrations and air viods for $N_{des,}$ $N_{ini,}$ and N_{max}

e. Mixing temperature.

f. Compaction temperature.

g. Temperature of mix when discharged from the mixer.

h. Temperature-viscosity relationship of the asphalt cement.

i. Plot of the combined gradation on the Federal Highway Administration (FHWA) 45 power gradation curve.

j. Graphical plots of the % G_{mm} @ N_{ini},%, % G_{mm} @ $N_{designn,}$ % G_{mm} @ N_{max}, air voids, voids in the mineral aggregate, and unit weight verses asphalt content.

k. Percent natural sand.

l.. Coarse Aggregate Angularity.

m. Percent elongated particles.

n. Tensile Strength Ratio (TSR).

o. Antistrip agent (if required).

p. Sand equivalent value of the fine aggregate.

q. Fine Aggregate Angularity of the combined blend.

r. Dust to asphalt ratio.

s. 75 Blow Marshall Stability and Marshall Air Voids at the design Asphalt Cement Content.

The Contractor shall submit samples to the Engineer, upon request, for job mix formula verification testing. The job mix formula for each mixture shall be in effect until modified in writing by the Engineer. Should a change in sources of materials be made, a new job mix formula must be approved in writing by the Engineer before the new material is used.

TABLE 1
SUPERPAVE DESIGN CRITERIA

Test Property	**Design Criteria for Nominal Maximum Aggregate Size**	
	3/4" Nom. (19 mm Nom.)	**1/2"Nom. (12.5 mm Nom.)**
Initial Number of Gyrations (N_{ini})	8	8
Design Number of Gyrations (N_{des})	100	100
Maximum Number of Gyrations (N_{max})	160	160
Air voids @ N_{des}	4.0	4.0
Voids in Mineral Aggregate @ N_{des}, %	13.0 min.	14.0 min
Voids filled with Asphalt @ N_{des}, %	65-78	65-78
Dust to asphalt ratio	0.8-1.6	0.8-1.6
Fine Aggregate Angularity	45 min.	45 min.
$\%G_{mm}$ @ N_{ini}	$\leq$90.50	$\leq$ 90.50
$\%G_{mm}$ @ N_{max}	$\leq$98.00	$\leq$ 98.00
Marshall Stability (average of 3 specimens)	Report	Report
Marshall Air Voids (average of 3 specimens)	Report	Report

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Note to Engineer – The Engineer shall specify the design criteria based on nominal maximum size aggregate. Unnecessary information should be deleted.

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(Table 2)
(RESERVED)

The mineral aggregate shall be of such size that the percentage composition by weight, as determined by laboratory screens, will conform to the gradation or gradations specified in Table 3 when tested in accordance with ASTM Standard C 136 and C 117. THE COMBINED GRADATION SHALL PASS BELOW (LOWER PERCENT PASSING) THE RESTRICTED ZONE. Gradations which extend slightly into the restricted zone may be evaluated for use by the Engineer.

The gradations in Table 3 represent the limits which shall determine the suitability of aggregate for use from the sources of supply. The aggregate, as selected (and used in the JMF), shall have a gradation within the limits designated in Table 3 and shall not vary from the low limit on one sieve to the high limit on the adjacent sieve, or vice versa, but shall be well graded from coarse to fine.

Deviations from the final approved mix design for bitumen content and gradation of aggregates shall be within the action limits for individual measurements as specified in paragraph 401-6.5a., PROVIDED DEVIATIONS FALL INSIDE THE CONTROL POINTS IN TABLE 3.

The nominal maximum size aggregate used shall not be more than one-third of the thickness of the course being constructed. For example, when the nominal maximum size is 1/2" (12.5 mm), the thickness of the course being constructed shall be 1-1/2" (37.5 mm) or more.

TABLE 3
AGGREGATE—BITUMINOUS PAVEMENTS

	¾-inch (19 mm)Nominal Maximum Size Aggregate				½-inch (12.5 mm) Nominal Maximum Size Aggregate			
Sieve Size	**Gradation Control Points Percent Passing by Weight**		**Restricted Zone Boundaries Percent Passing by Weight**		**Gradation Control Points Percent Passing by Weight**		**Restricted Zone Boundaries Percent Passing by Weight**	
	Min.	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**	**Min.**	**Max.**
1 in. (25.4 mm)	**100**	**100**						
¾ in. (19.0 mm)	**90**	**100**			**100**	**100**		
½ in. (12.5 mm)		**90**			**90**	**100**		
3/8 in. (9.5 mm)						**90**		
No. 4 (4.75 mm)								
No. 8 (2.36 mm)	**23**	**49**	**34.6**	**34.6**	**28**	**58**	**39.1**	**39.1**
No. 16 (1.18 mm)			**22.3**	**28.3**			**25.6**	**31.6**
No. 30 (0.60 mm)			**16.7**	**20.7**			**19.1**	**23.1**
No. 50 (0.30 mm)			**13.7**	**13.7**			**15.5**	**15.5**
No. 100 (0.15 mm)								
No. 200 (0.075 mm)	**2**	**8**			**2**	**10**		
Asphalt Cement Content (%)	**4.5**	**7.0**			**5.0**	**7.5**		

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Note to Engineer – The Engineer shall specify gradations based on the nominal maximum size aggregate. Unnecessary information should be deleted.

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The aggregate gradations shown are based on aggregates of uniform specific gravity. The percentages passing the various sieves shall be corrected when the specific gravity varies by 10 percent or more.

401-3.3 RECYCLED ASPHALT CONCRETE. Recycled asphalt concrete shall consist of reclaimed asphalt pavement (RAP), coarse aggregate, fine aggregate, mineral filler, and asphalt cement. RAP may be used for all courses.

The RAP shall be of a consistent gradation and asphalt content. The Contractor may obtain the RAP from the job site or an existing source.

All new aggregates used in the recycled mix shall meet the requirements of paragraph 401-2.1. New bituminous material shall meet the requirements of paragraph 401-2.3. The desired viscosity of the asphalt blend shall be obtained using only performance grade asphalts. A maximum of 25% RAP will be allowed in the Job Mix Formula. The RAP shall not contain any material that has been treated with a coal-tar sealer rejuvenator or material that contains coal-tar.

In addition to the requirements of paragraph 401-3.2, the job mix formula shall indicate the percent of reclaimed asphalt pavement.

The Contractor shall submit documentation to the Engineer, indicating that the mixing equipment proposed for use is adequate to mix the percent of RAP shown in the job mix formula and meet all local and national environmental regulations.

* *

Delete this paragraph if recycled asphalt pavement is not to be allowed and include a sentence that RAP will not be permitted.

* *

401-3.4 TEST SECTION. Prior to full production, the Contractor shall prepare and place a quantity of bituminous mixture according to the job mix formula. The amount of mixture should be sufficient to construct a test section **[ ]** long and **[ ]** wide placed in two lanes, with a longitudinal cold joint, and shall be of the same depth specified for the construction of the course which it represents. A cold joint is defined as an exposed construction joint at least four (4) hours old. The underlying grade or pavement structure upon which the test section is to be constructed shall be the same as the remainder of the course represented by the test section. The equipment used in construction of the test section shall be the same type and weight to be used on the remainder of the course represented by the test section.

The test section shall be evaluated for acceptance as a single lot in accordance with the acceptance criteria in paragraph 401-5.1 and 401-6.3. As a minimum the test section shall consist of 3 sublots.

The test section shall be considered acceptable if; 1) mat density, air voids (%G_{mm} @ N_{des}), and joint density are 90 percent or more within limits based on the PWL calculations, the 2) gradation and asphalt content are within the action limits specified in paragraphs 401-6.5a and 5b, and 3) the Voids in Mineral Aggregate @ N_{des}, Voids filled with Asphalt @ $N_{des,}$ Dust Proportion, %G_{mm} @ N_{ini}, and %G_{mm} @ N_{max} are within the limits of Table 1.

If the initial test section should prove to be unacceptable, the necessary adjustments to the job mix formula, plant operation, placing procedures, and/or rolling procedures shall be made. A second test section shall then be placed. If the second test section also does not meet specification requirements, both sections shall be removed at the Contractor's expense. Additional test sections, as required, shall be constructed and evaluated for conformance to the specifications. Any additional sections that are not acceptable shall be removed at the Contractor's expense. Full production shall not begin until an acceptable section has been constructed and accepted by the Engineer. The initial test section, whether acceptable or unacceptable, and any subsequent section that meets specification requirements shall be paid for in accordance with paragraph 401-8.1.

Job mix control testing shall be performed by the Contractor at the start of plant production and in conjunction with the calibration of the plant for the job mix formula. It should be recognized that the aggregates produced by the plant may not satisfy the gradation requirements or produce a mix that exactly meets the JMF. In those instances, it will be necessary to reevaluate and redesign the mix using plant-produced aggregates. Specimens should be prepared and the optimum bitumen content determined in the same manner as for the original design tests.

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The test section should be a minimum of 300 feet (90 m) long and 20 to 30 feet (6 to 9 m) wide. The test section affords the Contractor and the Engineer an opportunity to determine the quality of the mixture in place, as well as performance of the plant and laydown equipment.

Until the plant is producing the desired mix consistency, frequent testing may be necessary.

* *

401-3.5 TESTING LABORATORY. The laboratory used to develop the job mix formula shall meet the requirements of ASTM D 3666. A certification signed by the manager of the laboratory stating that it meets these requirements shall be submitted to the Engineer prior to the start of construction. The certification shall contain as a minimum:

a. Qualifications of personnel; laboratory manager, supervising technician, and testing technicians.

b. A listing of equipment to be used in developing the job mix.

c. A copy of the laboratory's quality control system.

d. Evidence of participation in the AASHTO Materials Reference Laboratory (AMRL) program

e. Evidence that the laboratory is accredited, for the test methods required herein by a nationally recognized laboratory accreditation organization.

CONSTRUCTION METHODS

401-4.1 WEATHER LIMITATIONS. The bituminous mixture shall not be placed upon a wet surface or when the surface temperature of the underlying course is less than specified in Table 4. The temperature requirements may be waived by the Engineer, if requested; however, all other requirements including compaction shall be met.

TABLE 4. BASE TEMPERATURE LIMITATIONS

Mat Thickness	Base Temperature (Minimum) Deg. F	Deg. C
3 in. (7.5 cm) or greater	40	4
Greater than 1 in. (2.5 cm) but less than 3 in. (7.5 cm)	45	7
1 in. (2.5 cm) or less	50	10

401-4.2 BITUMINOUS MIXING PLANT. Plants used for the preparation of bituminous mixtures shall conform to the requirements of ASTM D 995 with the following changes:

a. Requirements for All Plants.

(1) Truck Scales. The bituminous mixture shall be weighed on approved scales furnished by the Contractor, or on certified public scales at the Contractor's expense. Scales shall be inspected and sealed as often as the Engineer deems necessary to assure their accuracy. Scales shall conform to the requirements of the General Provisions, Section 90-01.

(2) Testing Facilities. The Contractor shall provide laboratory facilities at the plant for the use of the Engineer's acceptance testing and the Contractor's quality control testing, in accordance with paragraph 401-6.2d.

(3) Inspection of Plant. The Engineer, or Engineer's authorized representative, shall have access, at all times, to all areas of the plant for checking adequacy of equipment; inspecting operation of the plant: verifying weights, proportions, and material properties; and checking the temperatures maintained in the preparation of the mixtures.

(4) Storage Bins and Surge Bins. Paragraph 3.9 of ASTM D 995 is deleted. Instead, the following applies. Use of surge bins or storage bins for temporary storage of hot bituminous mixtures will be permitted as follows:

(a) The bituminous mixture may be stored in surge bins for period of time not to exceed 3 hours.

(b) The bituminous mixture may be stored in insulated storage bins for a period of time not to exceed 24 hours.

The bins shall be such that mix drawn from them meets the same requirements as mix loaded directly into trucks.

If the Engineer determines that there is an excessive amount of heat loss, segregation or oxidation of the mixture due to temporary storage, no overnight storage will be allowed.

401-4.3 HAULING EQUIPMENT. Trucks used for hauling bituminous mixtures shall have tight, clean, and smooth metal beds. To prevent the mixture from adhering to them, the truck beds shall be lightly coated with a minimum amount of paraffin oil, lime solution, or other approved material. Each truck shall have a suitable cover to protect the mixture from adverse weather. When necessary, to ensure that the mixture will be delivered to the site at the specified temperature, truck beds shall be insulated or heated and covers shall be securely fastened.

401-4.4 BITUMINOUS PAVERS. Bituminous pavers shall be self-propelled, with an activated screed, heated as necessary, and shall be capable spreading and finishing courses of bituminous plant mix material which will meet the specified thickness, smoothness, and grade. The paver shall have sufficient power to propel itself and the hauling equipment without adversely affecting the finished surface.

The paver shall have a receiving hopper of sufficient capacity to permit a uniform spreading operation. The hopper shall be equipped with a distribution system to place the mixture uniformly in front of the screed without segregation. The screed shall effectively produce a finished surface of the required evenness and texture without tearing, shoving, or gouging the mixture.

If an automatic grade control device is used, the paver shall be equipped with a control system capable of automatically maintaining the specified screed elevation. The control system shall be automatically actuated from either a reference line and/or through a system of mechanical sensors or sensor-directed mechanisms or devices which will maintain the paver screed at a predetermined transverse slope and at the proper elevation to obtain the required surface. The transverse slope controller shall be capable of maintaining the screed at the desired slope within plus or minus 0.1 percent.

The controls shall be capable of working in conjunction with any of the following attachments:

a. Ski-type device of not less than 30 feet (9.14 m) in length.

b. Taut stringline (wire) set to grade.

c. Short ski or shoe.

d. Laser control.

*** ***

For pavements serving aircraft 60,000 pounds (27 200 kg) or more gross weight and on all runways, it is recommended that the specifications require the use of automatic grade controls.

*** ***

401-4.5 ROLLERS. Rollers of the vibratory, steel wheel, and pneumatic-tired type shall be used. They shall be in good condition, capable of operating at slow speeds to avoid displacement of the bituminous mixture. The number, type, and weight of rollers shall be sufficient to compact the mixture to the required density while it is still in a workable condition.

The use of equipment which causes excessive crushing of the aggregate will not be permitted.

401-4.6 PREPARATION OF BITUMINOUS MATERIAL. The bituminous material shall be heated in a manner that will avoid local overheating and provide a continuous supply of the bituminous material to the mixer at a uniform temperature. The temperature of the bituminous material delivered to the mixer shall be sufficient to provide a suitable viscosity for adequate coating of the aggregate particles, but shall not exceed 325 degrees F (160 degrees C), unless otherwise required by the manufacturer.

401-4.7 PREPARATION OF MINERAL AGGREGATE. The aggregate for the mixture shall be heated and dried prior to introduction into the mixer. The maximum temperature and rate of heating shall be such that no damage occurs to the aggregates. The temperature of the aggregate and mineral filler shall not exceed 350 degrees

F (175 degrees C) when the asphalt is added. Particular care shall be taken that aggregates high in calcium or magnesium content are not damaged by overheating. The temperature shall not be lower than is required to obtain complete coating and uniform distribution on the aggregate particles and to provide a mixture of satisfactory workability.

401-4.8 PREPARATION OF BITUMINOUS MIXTURE. The aggregates and the bituminous material shall be weighed or metered and introduced into the mixer in the amount specified by the job mix formula.

The combined materials shall be mixed until the aggregate obtains a uniform coating of bitumen and is thoroughly distributed throughout the mixture. Wet mixing time shall be the shortest time that will produce a satisfactory mixture, but not less than 25 seconds for batch plants. The wet mixing time for all plants shall be established by the Contractor, based on the procedure for determining the percentage of coated particles described in ASTM D 2489, for each individual plant and for each type of aggregate used. The wet mixing time will be set to achieve 95 percent of coated particles. For continuous mix plants, the minimum mixing time shall be determined by dividing the weight of its contents at operating level by the weight of the mixture delivered per second by the mixer. The moisture content of all bituminous mix upon discharge shall not exceed 0.5 percent.

* *

For batch plants, wet mixing time begins with the introduction of bituminous material into the mixer and ends with the opening of the mixer discharge gate. Distribution of aggregate and bituminous material as they enter the pugmill, speed of mixer shafts, and arrangement and pitch of paddles are factors governing efficiency of mixing. Prolonged exposure to air and heat in the pugmill harden the asphalt film on the aggregate. Mixing time, therefore, should be the shortest time required to obtain uniform distribution of aggregate sizes and thorough coating of aggregate particles with bituminous material.

* *

401-4.9 PREPARATION OF THE UNDERLYING SURFACE. Immediately before placing the bituminous mixture, the underlying course shall be cleaned of all dust and debris. A prime coat or tack coat shall be applied in accordance with Item P-602 or P-603, if required by the contract specifications.

401-4.10 TRANSPORTING, PLACING, AND FINISHING. The bituminous mixture shall be transported from the mixing plant to the site in vehicles conforming to the requirements of paragraph 401-3. Deliveries shall be scheduled so that placing and compacting of mixture is uniform with minimum stopping and starting of the paver. Adequate artificial lighting shall be provided night placements. Hauling over freshly placed material shall not be permitted until the material has been compacted, as specified, and allowed to cool to atmospheric temperature.

[The Contractor may elect to use a material transfer vehicle to deliver mix to the paver.]

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Use of a material transfer vehicle allows the paver to be operated almost continuously without stopping between truckloads of mix, if a continuous supply of mix is available from the asphalt plant.

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The initial placement and compaction of the mixture shall occur at a temperature suitable for obtaining density, surface smoothness, and other specified requirements but not less than 250 degrees F (107 degrees C).

Upon arrival, the mixture shall be placed to the full width by a bituminous paver. It shall be struck off in a uniform layer of such depth that, when the work is completed, it shall have the required thickness and conform to the grade and contour indicated. The speed of the paver shall be regulated to eliminate pulling and tearing of the bituminous mat. Unless otherwise permitted, placement of the mixture shall begin along the centerline of a crowned section or on the high side of areas with a one-way slope. The mixture shall be placed in consecutive adjacent strips having a minimum width of **[ ]** except where edge lanes require less width to complete the area. The longitudinal joint in one course shall offset the longitudinal joint in the course immediately below by at least 1

foot (30 cm); however, the joint in the surface top course shall be at the centerline of the pavement. Transverse joints in one course shall be offset by at least 10 feet (3 m) from transverse joints in the previous course.

Transverse joints in adjacent lanes shall be offset a minimum of 10 feet (3 m).

On areas where irregularities or unavoidable obstacles make the use of mechanical spreading and finishing equipment impractical, the mixture may be spread and luted by hand tools.

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The Engineer should specify the widest paving lane practicable in an effort to hold the number of longitudinal joints to a minimum.

* *

401-4.11 COMPACTION OF MIXTURE. After placing, the mixture shall be thoroughly and uniformly compacted by rolling. The surface shall be compacted as soon as possible when the mixture has attained sufficient stability so that the rolling does not cause undue displacement, cracking or shoving. The sequence of rolling operations and the type of rollers used shall be at the discretion of the Contractor.
The speed of the roller shall, at all times, be sufficiently slow to avoid displacement of the hot mixture and be effective in compaction. Any displacement occurring as a result of reversing the direction of the roller, or from any other cause, shall be corrected at once.

Sufficient rollers shall be furnished to handle the output of the plant. Rolling shall continue until the surface is of uniform texture, true to grade and cross section, and the required field density is obtained.

To prevent adhesion of the mixture to the roller, the wheels shall be kept properly moistened (and scrapers used), but excessive water will not be permitted.

In areas not accessible to the roller, the mixture shall be thoroughly compacted with hand tampers.

Any mixture that becomes loose and broken, mixed with dirt, contains check-cracking, or in any way defective shall be removed and replaced with fresh hot mixture and immediately compacted to conform to the surrounding area. This work shall be done at the Contractor's expense. Skin patching shall not be allowed.

401-4.12 JOINTS. The formation of all joints shall be made in such a manner as to ensure a continuous bond between the courses and obtain the required density. All joints shall have the same texture as other sections of the course and meet the requirements for smoothness and grade.

The roller shall not pass over the unprotected end of the freshly laid mixture except when necessary to form a transverse joint. When necessary to form a transverse joint, it shall be made by means of placing a bulkhead or by tapering the course. The tapered edge shall be cut back to its full depth and width on a straight line to expose a vertical face prior to placing the adjacent lane. In both methods, all contact surfaces shall be given a tack coat of bituminous material before placing any fresh mixture against the joint.

Longitudinal joints which are irregular, damaged, uncompacted, or otherwise defective shall be cut back to expose a clean, sound surface for the full depth of the course. All contact surfaces shall be given a tack coat of bituminous material prior to placing any fresh mixture against the joint.

MATERIAL ACCEPTANCE

401-5.1 ACCEPTANCE SAMPLING AND TESTING. Unless otherwise specified, all acceptance sampling and testing necessary to determine conformance with the requirements specified in this section will be performed by the Engineer at no cost to the Contractor. Testing organizations performing these tests shall meet the requirements of ASTM D 3666. All equipment in Contractor furnished laboratories shall be calibrated by the testing organization prior to the start of operations. All Contractor personnel preparing laboratory compacted acceptance specimens shall be a state certified Superpave Field Testing Technician or equivalent acceptable to the Engineer.

a. Plant-Produced Material. Plant-produced material shall be tested for air voids on a lot basis. Sampling shall be from material behind the laydown operation in accordance with paragraph 401-5.1.a (1) Sampling. Acceptance samples, for each lot, shall not be obtained from the first 50 tons of plant-produced material unless multiple lots occur in one day of production. The first 50 tons of plant-produced material shall be included in the requirements of paragraph 401-5.1b. A lot will consist of:

- one day's production not to exceed 2,000 tons (1 814 000 kg), or

- a half day's production where a day's production is expected to consist of between 2,000 and 4,000 tons (1 814 000 and 3 628 000 kg), or

- similar subdivisions for tonnages over 4,000 tons (3 628 000 kg).

Where more than one plant is simultaneously producing material for the job, the lot sizes shall apply separately for each plant.

(1) Sampling. Each lot will consist of four equal sublots. Sufficient material for preparation of test specimens for all testing will be sampled by the Engineer on a random basis, in accordance with the procedures contained in ASTM D 3665. The Contractor shall prepare, under the supervision of the Engineer, the laboratory compacted test specimens and provide the Engineer with a printout of all data generated by the gyratory compaction equipment. One set of laboratory compacted specimens will be prepared, at the design number of gyrations required by paragraph 401-3.2, Table 1, for each sublot, in accordance with the compaction procedures outlined in Chapter 5, Superpave Level 1 Mix Design, of the Asphalt Institute's Manual Superpave Series No. 2 (SP-2), Superpave Level 1 Mix Design. Each set of laboratory compacted specimens will consist of two test portions prepared from the same sample increment.

The sample of bituminous mixture shall be maintained at a temperature at or above the specified compaction temperature for a period of no less than 30 minutes. If necessary, the sample shall be placed in an oven, for not more than 60 minutes, to bring the samples to the proper compaction temperature. The compaction temperatures shall be as specified in the job mix formula.

(2) Testing. Air voids will be determined by the Engineer in accordance with ASTM D 3203.

Prior to testing, the bulk specific gravity of each test specimen shall be measured by the Engineer in accordance with ASTM D 2726 using the procedure for laboratory-prepared thoroughly dry specimens, or ASTM D 1188, whichever is applicable, for use in computing air voids.

For air voids and pavement density, the theoretical maximum specific gravity of the mixture shall be measured for each sublot in accordance with ASTM D2041, Type C, D, or E container. The value used in the air voids computation for each sublot shall be based on the maximum specific gravity measurement performed for the sublot.

(3) Acceptance. Acceptance of plant-produced material for air voids shall be determined by the Engineer in accordance with the requirements of paragraph 401-5.2b.

b. Field Placed Material. Material placed in the field shall be tested for mat and joint density on a lot basis.

(1) Mat Density. The lot size shall be the same as that indicated in paragraph 401-5.1.a and shall be divided into four equal sublots. One 6-inch diameter core of finished, compacted materials shall be taken by the Contractor from each sublot. Core locations will be determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. Cores shall not be taken closer than one foot from a transverse or longitudinal joint.

(2) Joint Density. The lot size shall be the total length of longitudinal joints constructed by a lot of material as defined in paragraph 401-5.1a. The lot shall be divided into four equal sublots. One 6-inch diameter core of finished, compacted materials shall be taken by the Contractor from each sublot. Core locations will be

determined by the Engineer on a random basis in accordance with procedures contained in ASTM D 3665. All coring shall be centered on the joint.

(3) Sampling. Samples shall be neatly cut with a core drill. The cutting edge of the core drill bit shall be of hardened steel or other suitable material with diamond chips embedded in the metal cutting edge. The minimum diameter of the sample shall be three inches. Samples that are clearly defective, as a result of sampling, shall be discarded and another sample taken. The Contractor shall furnish all tools, labor, and materials for cutting samples and filling the cored pavement. Cored holes shall be filled in a manner acceptable to the Engineer and within one day after sampling.

(4) Testing. The bulk specific gravity of each cored sample will be measured by the Engineer in accordance with ASTM D 2726 or ASTM D 1188, whichever is applicable. The percent compaction (density) of each sample will be determined by dividing the bulk specific gravity of each sublot sample by the maximum theoretical specific gravity for that sublot, as determined by paragraph 401-5.1a(2). The maximum theoretical specific gravity used to determine the joint density at joints between two different lots shall be the lower of the specific gravity values from the two different lots.

(5) Acceptance. Acceptance of field placed material for mat density will be determined by the Engineer in accordance with the requirements of paragraph 401-5.2c. Acceptance for joint density will be determined in accordance with the requirements of paragraph 401-5.2d.

c. Partial Lots - Plant-Produced Material. When operational conditions cause a lot to be terminated before the specified number of tests have been made for the lot, or when the Contractor and Engineer agree in writing to allow overages or other minor tonnage placements to be considered as partial lots, the following procedure will be used to adjust the lot size and the number of tests for the lot.

The last batch produced where production is halted will be sampled, and its properties shall be considered as representative of the particular sublot from which it was taken. Where three sublots are produced, they shall constitute a lot. Where one or two sublots are produced, they shall be incorporated into the next lot, and the total number of sublots shall be used in the acceptance plan calculation, i.e., n = 5 or n = 6, for example.

d. Partial Lots - Field Placed Material. The lot size for field placed material shall correspond to that of the plant material, except that, in no cases, less than (3) cored samples shall be obtained for the acceptance plan calculations, i.e., n = 3.

401-5.2 ACCEPTANCE CRITERIA.

a. General. Acceptance will be based on the following characteristics of the bituminous mixture and completed pavement as well as the implementation of the Contractor's Quality Control plan and test results:

(1) Air voids	**(3)** Joint density	**(5)** Smoothness
(2) Mat density	**(4)** Thickness	**(6)** Grade

Air voids, mat density, and joint density will be evaluated for acceptance on a lot basis using the method of estimating percentage of material within specification limits (PWL). Acceptance using PWL considers the variability (standard deviation) of the material and the testing procedures, as well as the average (mean) value of the test results to calculate the percentage of material that is above the lower specification tolerance limit (L) or below the upper specification tolerance limit (U).

Thickness will be evaluated by the Engineer for compliance in accordance with paragraph 401-5.2.f(4). Acceptance for smoothness will be based on the criteria contained in paragraph 401-5.2f(5). Acceptance for grade will be based on the criteria contained in paragraph 401-5.2f(6).

The Engineer may at any time, not withstanding previous plant acceptance, reject and require the Contractor to dispose of any batch of bituminous mixture which is rendered unfit for use due to contamination, segregation, incomplete coating of aggregate, or improper mix temperature. Such rejection may be based on only visual inspection or temperature measurements. In the event of such rejection, the Contractor may take a representative

sample of the rejected material in the presence of the Engineer, and, if it can be demonstrated in the laboratory, in the presence of the Engineer, that such material was erroneously rejected, payment will be made for the material at the contract unit price.

b. Air Voids. Evaluation for acceptance of each lot of plant produced material for air voids shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher. Consistently producing at a target air void content between 3.35 and 4.65 percent with a standard deviation of 0.65 percent will result in an average PWL of 90.

c. Mat Density. Evaluation for acceptance of each lot of in-place pavement for mat density shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher. Consistently producing at a target mat density of 94 percent with a standard deviation of 1.2 percent will result in an average PWL of 90.

d. Joint Density. Evaluation for acceptance of each lot of in-place pavement for joint density shall be based on PWL. The Contractor shall target production quality to achieve 90 PWL or higher. Consistently producing at a target joint density of 92.3 percent with a standard deviation of 1.8 percent will result in an average PWL of 90. Consistently producing at a target joint density of 91.5 percent with a standard deviation of 1.8 percent will result in an average PWL of 80. Consistently producing at a target joint density of 91.0 percent with a standard deviation of 1.8 percent will result in an average PWL of 71.

e. Percentage of Material Within Specification Limits (PWL). The percentage of material within specification limits (PWL) shall be determined in accordance with procedures specified in Section 110 of the General Provisions. The specification tolerance limits (L) and (U) are contained in Table 5.

TABLE 5

ACCEPTANCE LIMITS

	Specification Tolerance Limits	
Test Property	**Lower**	**Upper**
Air Voids, (% @ N_{des})	2.5	5.5
Mat Density, $\%G_{mm}$	92.5	
Joint Density, $\%G_{mm}$	90.0	

f. Acceptance Criteria.

(1) Mat Density and Air Voids. If the PWL of the lot equals or exceeds 90 percent, the lot shall be acceptable. Acceptance and payment for the lot shall be determined in accordance with paragraph 401-8.1.

(2) Paragraph reserved.

(3) Joint Density. If the PWL of the lot is equal to or exceeds 90 percent, the lot shall be considered acceptable. If the PWL is less than 90 percent, the Contractor shall evaluate the reason and act accordingly. If the PWL is less than 80 percent, the Contractor shall cease operations and until the reason for poor compaction has been determined. If the PWL is less than 71 percent, the lot pay factor for the first lot used to complete the joint shall be reduced by 5 percentage points. This lot pay factor reduction shall be incorporated and evaluated in accordance with paragraph 401-8.1.

(4) Thickness. Thickness shall be evaluated for compliance by the Engineer to the requirements shown on the plans. Measurements of thickness shall be made by the Engineer using the cores extracted for each sublot for density measurement.

(5) Smoothness. The finished surfaces of the pavement shall not vary more than **[ ]** for the **[surface] [base]** course. Each lot shall be evaluated with a 12-foot (3.6 m) straightedge. The lot size shall be **[ ]**

square yards (square meters). Measurements will be made perpendicular and parallel to the centerline at distances not to exceed 50 feet (15.2 m). When more than 15 percent of all measurements within a lot exceed the specified tolerance, the Contractor shall remove the deficient area and replace with new material. Sufficient material shall be removed to allow at least one inch of asphalt concrete to be placed. Skin patching shall not be permitted. High points may be ground off.

* *

Specify 3/8 inch (9.5 mm) for base course and 1/4 inch (6.2 mm) for surface course.

The Engineer shall specify the lot size. A minimum of 2,000 square yards (1 650 square meters) is recommended.

* *

(6) Grade. The finished surface of the pavement shall not vary from the gradeline elevations and cross sections shown on the plans by more than 1/2 inch (12.70 mm). The finished grade of each lot will be determined by running levels at intervals of 50 feet (15.2 m) or less longitudinally and transversely to determine the elevation of the completed pavement. The lot size shall be **[ ]** square yards (square meters). When more than 15 percent of all the measurements within a lot are outside the specified tolerance, the Contractor shall remove the deficient area and replace with new material. Sufficient material shall be removed to allow at least **[1-1/2” (37.5 mm)] [2” (51 mm)]** of asphalt concrete to be placed. Skin patching for correcting low areas shall not be permitted. High points may be ground off.

* *

A minimum lot size of 2,000 square yards (1 650 square meters) is recommended.

* *

g. Outliers. All individual tests for mat density and air voids shall be checked for outliers (test criterion) in accordance with ASTM E 178, at a significance level of 5 percent. Outliers shall be discarded, and the PWL shall be determined using the remaining test values.

401-5.3 RESAMPLING PAVEMENT.

a. General. Resampling of a lot of pavement for mat density will be allowed if the Contractor requests, in writing, within 48 hours after receiving the written test results from the Engineer. A retest will consist of all the sampling and testing procedures contained in paragraphs 401-5.1b and 401-5.2c. Only one resampling per lot will be permitted.

(1) A redefined PWL shall be calculated for the resampled lot. The number of tests used to calculate the redefined PWL shall include the initial tests made for that lot plus the retests.

(2) The cost for resampling and retesting shall be borne by the Contractor.

b. Payment for Resampled Lots. The redefined PWL for a resampled lot shall be used to calculate the payment for that lot in accordance with Table 6.

c. Outliers. If the tests within a lot include a very large or a very small value which appears to be outside the normal limits of variation, check for an outlier in accordance with ASTM E 178, at a significance level of 5 percent, to determine if this value should be discarded when computing the PWL.

[401-5.4 LEVELING COURSE. Any variable thickness course, indicated on the plans, used for truing and leveling shall meet the requirements of paragraph 401-3.2 and 5.2b, but shall not be subject to the density requirements of paragraph 401-5.2c and d. The leveling course shall be compacted with the same effort used to achieve density of the test section. The truing and leveling course shall not exceed a nominal thickness of 1-1/2 inches (37.5 mm).]

* *

Use this paragraph only when there is a need to restore proper cross-section prior to overlaying. Areas of the pavement requiring a leveling course shall be shown on the plans.

* *

CONTRACTOR QUALITY CONTROL

401-6.1 GENERAL. The Contractor shall develop a Quality Control Program in accordance with Section 100 of the General Provisions. The program shall address all elements which effect the quality of the pavement including, but not limited to:

a. Mix Design
b. Aggregate Grading
c. Quality of Materials
d. Stockpile Management
e. Proportioning
f. Mixing and Transportation
g. Placing and Finishing
h. Joints
i. Compaction
j. Surface smoothness

401-6.2 TESTING LABORATORY. The Contractor shall provide a fully equipped asphalt laboratory located at the plant or job site. It shall be available for joint use by the Contractor for quality control testing and by the Engineer for acceptance testing and must have adequate equipment for the performance of the tests required by these specifications. The Engineer shall have priority in use of the equipment necessary for acceptance testing.

The effective working area of the laboratory shall be a minimum of 150 square feet (14 square meters) with a ceiling height of not less than 7.5 feet (2.3 meters). Lighting shall be adequate to illuminate all working areas. It shall be equipped with heating and air conditioning units to maintain a temperature of 70 degrees F + 5 degrees (21 degrees C + 2.3 degrees C).

Laboratory facilities shall be kept clean and all equipment shall be maintained in proper working condition. The Engineer shall be permitted unrestricted access to inspect the Contractor's laboratory facility and witness quality control activities. The Engineer will advise the Contractor in writing of any noted deficiencies concerning the laboratory facility, equipment, supplies, or testing personnel and procedures. When the deficiencies are serious enough to be adversely affecting test results, the incorporation of the materials into the work shall be suspended immediately and will not be permitted to resume until the deficiencies are satisfactorily corrected.

401-6.3 QUALITY CONTROL TESTING. The Contractor shall perform all quality control tests necessary to control the production and construction processes applicable to these specifications and as set forth in the Quality Control Program. The testing program shall include, but not necessarily limited to, tests for the control of asphalt content, aggregate gradation, temperatures, aggregate moisture, field compaction, and surface smoothness. A Quality Control Testing Plan shall be developed as part of the Quality Control Program.

a. Asphalt Content. A minimum of two extraction tests shall be performed per lot in accordance with ASTM D 2172 or ASTM D 6307 for determination of asphalt content. The weight of ash portion of the extraction test, as described in ASTM D 2172, shall be determined as part of the first extraction test performed at the beginning of plant production; and as part of every tenth extraction test performed thereafter, for the duration of plant production. The last weight of ash value obtained shall be used in the calculation of the asphalt content for the mixture.

The use of the nuclear method for determining asphalt content in accordance with ASTM D 4125 is permitted, provided that it is calibrated for the specific mix being used.

The use of an ignition binder oven for determining asphalt content in accordance with ASTM D-6307 (formerly PS90) is permitted, provided that it is calibrated for the specific mix being used. This calibration shall be provided to the Engineer prior to the start of production. The Engineer reserves the right to verify the calibration of any equipment.

b. Gradation. Aggregate gradations shall be determined a minimum of twice per lot from mechanical analysis of extracted aggregate in accordance with AASHTO T 30 and ASTM C 136 (Dry Sieve). When asphalt content is determined by the nuclear method, aggregate gradation shall be determined from hot bin samples on batch plants, or from the cold feed on drum mix or continuous mix plants, and tested in accordance with ASTM C 136 (dry sieve) using actual batch weights to determine the combined aggregate gradation of the mixture. If RAP is used in the mix and the asphalt content is determined by the ignition method, aggregate gradations shall be determined from mechanical analysis of the extracted (ignited) aggregate in accordance with AASHTO T30 or ASTM C117 and ASTM C136 (Dry Sieve). If RAP is not used in the mix and the asphalt content is determined by the ignition method, aggregate gradations shall be determined from a mechanical analysis of the combined virgin aggregate, taken just prior to introduction into the dryer drum or mixer, and tested in accordance with ASTM C117 and ASTM C136 (Dry Sieve).

c. Fine Aggregate Angularity. The fine aggregate angularity of the fine aggregate used for production shall be determined once per lot in accordance with AASHTO T304, Method A.

d. Moisture Content of Aggregate. The moisture content of the aggregate used for production shall be determined once per lot in accordance with ASTM C 566

e. Moisture Content of Mixture. The moisture content of the mixture shall be determined once per lot in accordance with ASTM D 1461. If it exceeds 0.5% by weight of dry mix, the Contractor shall cease production until an action acceptable to the Engineer is taken.

f. Temperatures. Temperatures shall be checked, at least four times per lot, at necessary locations to determine the temperatures of the dryer, the bitumen in the storage tank, the mixture at the plant, and the mixture at the job site.

g. In-Place Density Monitoring. The Contractor shall conduct any necessary testing to ensure that the specified density is being achieved. A nuclear gauge may be used to monitor the pavement density in accordance with ASTM D 2950.

h. Additional Testing. Any additional testing that the Contractor deems necessary to control the process may be performed at the Contractor's option.

i. Monitoring. The Engineer reserves the right to monitor any or all of the above testing.

j. Aggregate Quality. The Contractor shall perform specific gravity and absorption tests on all aggregates used. These tests will be run at least one per week. If the specific gravity parameters vary more than plus or minus 10 percent of the values obtained in the mix design, the Contractor will be required to submit a new job mix formula.

401-6.4 SAMPLING. When directed by the Engineer, the Contractor shall sample and test any material which appears inconsistent with similar material being sampled, unless such material is voluntarily removed and replaced or deficiencies corrected by the Contractor. All sampling shall be in accordance with standard procedures specified.

401-6.5 CONTROL CHARTS. The Contractor shall maintain linear control charts both for individual measurements and range (i.e., difference between highest and lowest measurements) for aggregate gradation and asphalt content.

Control charts shall be posted in a location satisfactory to the Engineer and shall be kept current. As a minimum, the control charts shall identify the project number, the contract item number, the test number, each test parameter, the Action and Suspension Limits applicable to each test parameter, and the Contractor's test results. The Contractor shall use the control charts as part of a process control system for identifying potential problems and assignable causes before they occur. If the Contractor's projected data during production indicates a problem and the Contractor is not taking satisfactory corrective action, the Engineer may suspend production or acceptance of the material.

a. Individual Measurements. Control charts for individual measurements shall be established to maintain process control within tolerance for aggregate gradation and asphalt content. The control charts shall use the job mix formula target values as indicators of central tendency for the following test parameters with associated Action and Suspension Limits:

CONTROL CHART LIMITS FOR INDIVIDUAL MEASUREMENTS

Sieve	Action Limit	Suspension Limit
1 inch (25.0 mm)	0%	0%
3/4 inch (19.0 mm)	+/-6%	+/-9%
1/2 inch (12.5 mm)	+/-6%	+/-9%
3/8 inch (9.5 mm)	+/-6%	+/-9%
No. 4 (4.75 mm)	+/-6%	+/-9%
No. 16 (1.18 mm)	+/-5%	+/-7.5%
No. 50 (0.30 mm)	+/-3%	+/-4.5%
No. 200 (0.075 mm)	+/-2%	+/-3%
Asphalt Content	+/-0.45%	+/-0.70%

b. Range. Control charts for range shall be established to control process variability for the test parameters and Suspension Limits listed below. The range shall be computed for each lot as the difference between the two test results for each control parameter. The Suspension Limits specified below are based on a sample size of n = 2. Should the Contractor elect to perform more than two tests per lot, the Suspension Limits shall be adjusted by multiplying the Suspension Limit by 1.18 for n = 3 and by 1.27 for n = 4.

CONTROL CHART LIMITS BASED ON RANGE
(Based on n = 2)

Sieve	Suspension Limit
3/4 inch (19 mm)	11 percent
1/2 inch (12.5 mm)	11 percent
3/8 inch (9.5 mm)	11 percent
No. 4 (4.75 mm)	11 percent
No. 16 (1.18 mm)	9 percent
No. 50 (0.30 mm)	6 percent
No. 200 (0.075 mm)	3.5 percent
Asphalt Content	0.8 percent

c. Corrective Action. The Quality Control Plan shall indicate that appropriate action shall be taken when the process is believed to be out of tolerance. The Plan shall contain sets of rules to gauge when a process is out of control and detail what action will be taken to bring the process into control. As a minimum, a process shall be deemed out of control and production stopped and corrective action taken, if:

(1) One point falls outside the Suspension Limit line for individual measurements or range; or

(2) Two points in a row fall outside the Action Limit line for individual measurements.

(3) ANY LIMIT THAT FALLS OUTSIDE THE CONTROL POINTS IN TABLE 3.

* *

The aggregate control chart parameters and Suspension and Action Limits contained in the above paragraphs are based on 3/4 inch (19.0 mm) nominal maximum size aggregate gradation.

When 1/2-inch (12.5 mm) nominal maximum size aggregate is specified, the 1-inch (25.0 mm) sieves should be deleted from the Individual Measurements Chart and the 1/2-inch (12.5 mm) sieve Action and Suspension Limits should be changed to 0%. For the 1/2-inch (12.5 mm) gradation, the 1/2-inch sieve should be deleted from the Range Chart.

* *

401-6.6 Additional Plant-Produced Material Testing. The Contractor shall obtain one sample per lot from material behind the laydown operation in accordance with paragraph 401-5.1.a (1) Sampling. Samples shall not be obtained from the first 50 tons of plant-produced material unless multiple lots occur in one day of production. Sufficient material for preparation of three test specimens for testing in accordance with ASTM D 1559(93), paragraph 4.5, using 75 blows per face.

The sample of bituminous mixture shall be maintained at a temperature at or above the specified compaction temperature for a period of no less than 30 minutes. If necessary, the sample shall be placed in an oven, for not more than 60 minutes, to bring the samples to the proper compaction temperature. The compaction temperatures shall be as specified in the job mix formula.

The specimens shall be tested for stability and flow in accordance with ASTM D 1559 (93), paragraph 5., or AASHTO T 245.

Prior to testing, the bulk specific gravity of each test specimen shall be measured by the Contractor in accordance with ASTM D 2726 using the procedure for laboratory-prepared thoroughly dry specimens, or ASTM D 1188, whichever is applicable.

The stability, flow, and bulk specific gravity for each lot shall be computed by averaging the results of all test specimens representing that lot and reported to the Engineer in writing.

METHOD OF MEASUREMENT

401-7.1 MEASUREMENT. Plant mix bituminous concrete pavement shall be measured by the number of tons (kg) of bituminous mixture **[and the number of tons (kg) of bituminous material]** used in the accepted work. Recorded batch weights or truck scale weights will be used to determine the basis for the tonnage. **[The weight of bituminous material shall be adjusted in accordance with the percentage of bitumen as determined in paragraph 401-6.3a.]**

BASIS OF PAYMENT

401-8.1 PAYMENT. Payment for an accepted lot of bituminous concrete pavement shall be made at the contract unit price per ton (kg) for bituminous mixture **[and bituminous material]** adjusted according to paragraph 401-8.1a, subject to the limitation that:

> The total project payment for plant mix bituminous concrete pavement shall not exceed **[ ]** percent of the product of the contract unit price and the total number of tons (kg) of bituminous mixture **[,and [ ] percent of the product of the contract unit price and the number of tons (kg) of bituminous material]** used in the accepted work (See Note 2 under Table 6).

The price shall be compensation for furnishing all materials, for all preparation, mixing, and placing of these materials, and for all labor, equipment, tools, and incidentals necessary to complete the item.

* *

The Engineer shall specify a value ranging from 100 to 106 percent. When the total project payment for Item P-401 pavement exceeds the contract unit price, any AIP or PFC funds used to pay the excess may require an amendment to the AIP grant or PFC application for the project.

* *

a. Basis of Adjusted Payment. The pay factor for each individual lot shall be calculated in accordance with Table 6. A pay factor shall be calculated for both mat density and air voids. The lot pay factor shall be the higher of the two values when calculations for both mat density and air voids are 100 percent or higher. The lot pay factor shall be the product of the two values when only one of the calculations for either mat density or air voids is 100 percent or higher. The lot pay factor shall be the lower of the two values when calculations for both mat density and air voids are less than 100 percent. The lot pay factor shall be reduced as necessary per paragraph 401-5.2f(3) Joint Density. **[The lot pay factor shall apply to both the bituminous mixture and the bituminous material.]**

TABLE 6. PRICE ADJUSTMENT SCHEDULE [1]

Percentage of Material Within Specification Limits (PWL)	Lot Pay Factor (Percent of Contract Unit Price)
96 – 100	106
90 – 95	PWL + 10
75 – 89	0.5PWL + 55
55 – 74	1.4PWL – 12
Below 55	Reject [2]

[1] ALTHOUGH IT IS THEORETICALLY POSSIBLE TO ACHIEVE A PAY FACTOR OF 106 PERCENT FOR EACH LOT, ACTUAL PAYMENT ABOVE 100 PERCENT SHALL BE SUBJECT TO THE TOTAL PROJECT PAYMENT LIMITATION SPECIFIED IN PARAGRAPH 401-8.1.

[2] The lot shall be removed and replaced. However, the Engineer may decide to allow the rejected lot to remain. In that case, if the Engineer and Contractor agree in writing that the lot shall not be removed, it shall be paid for at 50 percent of the contract unit price AND THE TOTAL PROJECT PAYMENT LIMITATION SHALL BE REDUCED BY THE AMOUNT WITHHELD FOR THE REJECTED LOT.

For each lot accepted, the adjusted contract unit price shall be the product of the lot pay factor for the lot and the contract unit price. Payment shall be subject to the total project payment limitation specified in paragraph 501-8.1. Payment in excess of 100 percent for accepted lots of bituminous concrete pavement shall be used to offset payment for accepted lots of bituminous concrete pavement that achieve a lot pay factor less than 100 percent.

b. Payment. Payment will be made under:

Item P-401-8.1a Bituminous **[Surface] [Base]** Course--per ton (kg)

[Item P-401-8.1b Bituminous Material--per ton (kg)]

TESTING REQUIREMENTS

ASTM C 29	Unit Weight of Aggregate
ASTM C 88	Soundness of Aggregates by Use of Sodium Sulfate or Magnesium Sulfate
ASTM C 117	Test Method for Materials Finer than 75-um (No.200) Sieve in Mineral Aggregates by Washing
ASTM C 131	Resistance to Abrasion of Small Size Coarse Aggregate by Use of the Los Angeles Machine
ASTM C 136	Sieve or Screen Analysis of Fine and Coarse Aggregates
ASTM C 183	Sampling Hydraulic Cement
ASTM C 566	Total Moisture Content of Aggregate by Drying
ASTM D 75	Sampling Aggregates
ASTM D 995	Requirements for Mixing Plants for Hot-Mixed Hot-Laid Bituminous Paving Mixtures
ASTM D 118	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Paraffin-Coated Specimens
ASTM D 1461	Moisture or Volatile Distillates in Bituminous Paving Mixtures
ASTM D 1559-93	Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus
ASTM D 2041	Theoretical Maximum Specific Gravity and Density of Bituminous Paving Mixtures
ASTM D 2172	Quantitative Extraction of Bitumen from Bituminous Paving Mixtures
ASTM D 2419	Sand Equivalent Value of Soils and Fine Aggregate
ASTM D 2489	Degree of Particle Coating of Bituminous-Aggregate Mixtures
ASTM D 2726	Bulk Specific Gravity of Compacted Bituminous Mixtures Using Saturated Surface-Dry Specimens
ASTM D 3203	Percent Air Voids in Compacted Dense and Open Bituminous Paving Mixtures
ASTM D 2950	Density of Bituminous Concrete in Place by Nuclear Method
ASTM D 3665	Random Sampling of Paving Materials
ASTM D 3666	Inspection and Testing Agencies for Bituminous Paving Materials
ASTM D 4125	Asphalt Content of Bituminous Mixtures by the Nuclear Method
ASTM D 4318	Liquid Limit, Plastic Limit, and Plasticity Index of Soils
ASTM D 4791	Flat or Elongated Particles in Coarse Aggregate
ASTM D 4867	Effect of Moisture on Asphalt Concrete Paving Mixtures
ASTM D 5821	Standard Test Method for determining the percentage of Fractured Particles in Coarse Aggregate
ASTM D 6307	Asphalt Content of Hot Mix Asphalt by Ignition Method.

ASTM E 178 Practice for Dealing With Outlying Observations

AASHTO T 30 Mechanical Analysis of Extracted Aggregate

AASHTO T 245 Resistance to Plastic Flow of Bituminous Mixtures Using Marshall Apparatus

AASHTO T 304 Test for Fine Aggregate Angularity (Method A)

Manual SP-1 Asphalt Institute Superpave Asphalt Binder Specification

Manual SP-2 Asphalt Institute Superpave Level I Mix design

MATERIAL REQUIREMENTS

ASTM D 242 Mineral Filler for Bituminous Paving Mixtures

ASTM D 946 Asphalt Cement for Use in Pavement Construction

ASTM D 4552 Classifying Hot-Mix Recycling Agents

AASHTO MP1 Performance Graded Binder Designation